"A Microcontroller Based smart helmet for coal miners for air quality and hazardous event detection"

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Abstract

A classic model of smart helmet has been developed to assist miners working in the mining industry. Many dangerous events tend to occur in mining industry that can lead to life-threatening injury or to be fatal. Miners helmet is most commonly and compulsorily used. But it does not improve the safety of miners apart from providing illumination. A smart helmet has been able to detect all dangerous events with the help of sensors. Gas sensor will detect poisonous gases like CO, CH4, LPG and natural gases. Collision sensor will detect by which pressure miners will be affected by heavy object fall and IR sensor will detect whether helmet is removed or not. Data is transmitted wirelessly through RF module. Each sensor has critical value, if reached then buzzer will automatically switch on giving an alert signal to the miners and supervisors. Thus smart helmet prevents miners from suffering upcoming accidents.

Keywords: *Mine Safety, Wireless communication*.

I. INTRODUCTION:

Mining is the process of extracting valuable minerals from the earth .In today's world, mining plays an important role due to need for metals and other minerals. The material obtained from mining include aluminium, copper, lead, Zinc, gold, diamond, metals, coal etc. Coal plays an important role in the generation of electricity. Coal is extract from the earth by surface mining and underground mining. In underground mining, disaster is very serious issue. So, the safety and security of mine workers is an important factor.

In coal mines, safety equipment like helmet and shoes are not in proper condition. Sometimes miners remove their helmet just because they are not comfortable to work with it. In coal mines dangerous events like heavy object fall and presence of dangerous gases like CO,CH4, LPG occurs. When human being comes in contact with such dangerous gases they may suffer cardiovascular disease. Removal of helmet while working in mines is also dangerous. If heavy object falls on miners head even wearing his helmet, a person may become unconscious and may die if proper treatment is not provided on the time. A smart helmet is designed which is able to detect all these dangerous events with the help of sensors which are mounted in it. A sensor circuit which is mounted in the helmet of each miner will observe the environmental changes also the pressure by which miner is affected. During the development of safety helmet we consider mainly 3 factors. First is the presence of dangerous gases, second is helmet removal by the miners and third one is miner hit by an object. A wired communication system in the form of cabling and pipeline can be used but in mining industry in case of gas explosion and rock fall the system may become damaged. Also the installation and maintenances cost of the cabling is high so wireless communication system is used to transfer data wirelessly to the monitoring station. RF module is used to transfer data which can support multiple baud rate and range of the system is also high.

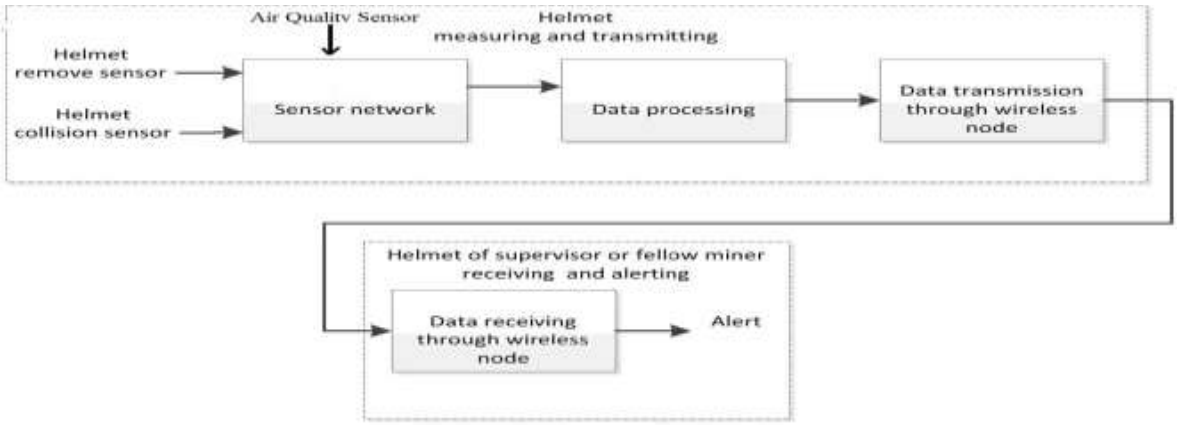


Figure 1: represents the block diagram of the smart helmet for mining safety.

II. WORKING:

The intelligent and data alert system of smart helmet is mounted with sensor circuit. The transmitter section consist of Aurdino, gas sensor (MQ-4), helmet removal sensor (IR sensor), collision sensor(MMA7461L), RF module for transmission and receiving data and additionally a buzzer is provided. Analog input from sensor is provided to the analog pins of Aurdino (pin A0 to A5), RF module transmits this data to the repeater section repeater receive and transmits the data so that strength of signal should not be lost. Repeater section consists of ATMEGA16 Signal from repeater sent to the receiving section which consist microcontroller AVR ATEMGA16. It converts analog signal to digital and respected output will be displayed on LCD display.

III. SYSTEM ARCHICTURE:

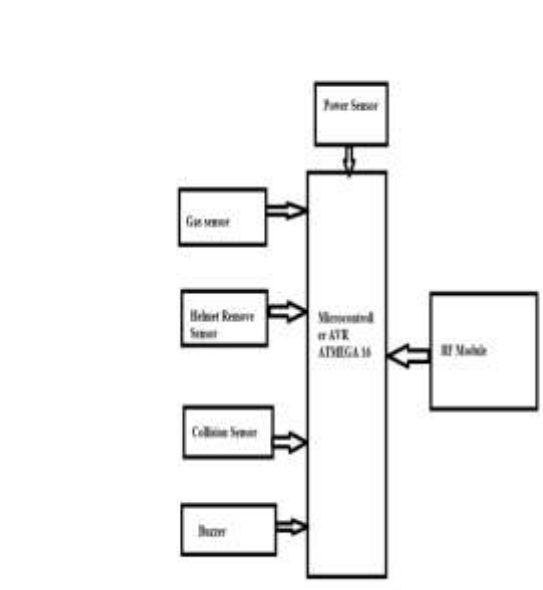


Fig.2. Block Diagram of Transmitter

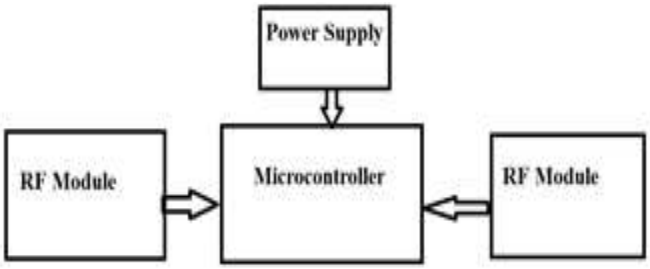


Fig.3. Block diagram of Repeater

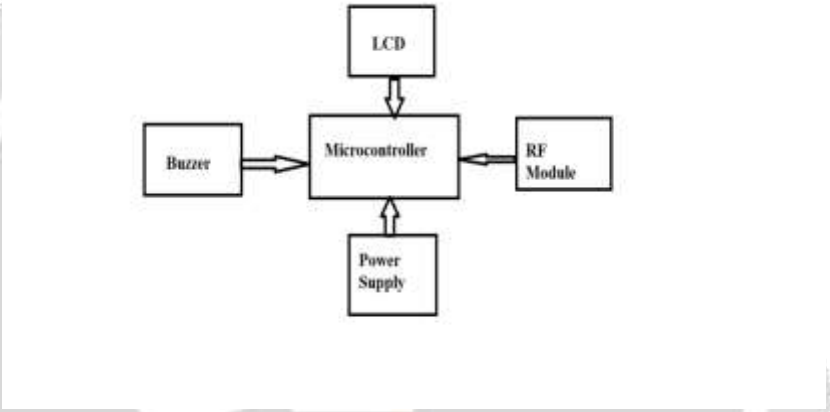


Fig.4. Block Diagram of Receiver

Fig (2) shows the block diagram of transmitter. The transmitter is placed in helmet which senses the signal if any catastrophe occurs and then send the signal to the repeater. The block diagram of repeater is shown in fig 3. The receiver is also called as monitoring station which receives the signal generated at helmet unit. The various parameters related to helmet unit is displayed on 16 x2 LCD screen. Figure 4 shows the block diagram of receiver. The helmet section consists of gas, Collision and helmet removal sensors, RF receiver, LCD Display, and RF transmitter for communication microcontroller AVR ATmega-16 is used [1]. Input to the microcontroller Collision, gas, helmet removal sensors outputs, LCD, RF Module. Output pins of the controller are connected to LCD display and RF module as shown in the fig.1. MQ-4 is the gas sensor used which has the sensitive material CO, LPG, CH4.

The receiver section receives the data and displays it in the LCD Display Device shown in fig.4. An RF receiver is given at the input section and it is used to receive RF signals transmitted by RF transmitters at the coal mine. The receiver section receives the data and displays it on LCD.

IV. HARDWARE

A] SENSOR NETWORK

- **Collision Sensor-**
  - The IR Sensor-Single is a general purpose proximity sensor. Here we use it for collision detection. The module consist of an IR emitter and IR receiver pair. The high precision IR receiver always detects an IR signal.

- The module consists of 358 comparator IC. The output of sensor is high whenever it receives IR frequency and low otherwise. The on-board LED indicator helps user to check status of the sensor without using any additional hardware.
- The power consumption of this module is low.

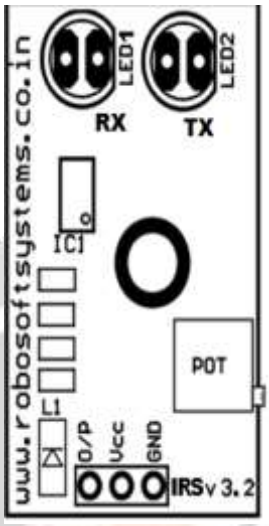


FIG: IR sensor

➢ **Gas Senor**:-

In this project MQ-4 sensor is used as a gas sensor. It is able to identify various gases in the air like CO, CH4, LPG and natural gases. MQ-4 sensor is highly sensitive to LPG .

Methane gas is released from coal beds to the surrounding atmosphere. It is odourless, colourless, flammable and lighter than air thus difficult to detect its presence in air. Sensor composed by Micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-4 have 6 pin,4 of them are used to fetch signals, and other 2 are used for providing heating current.

Fig : Gas sensor MQ-4

➢ **Helmet Removal Sensor**:-

To detect whether the miner has removed his helmet or not, we use here MMA7461L accelerometer. It is low power, low profile capacitive micro machined accelerometer.

Fig: Bottom view of MMA7461L

B] MICROCONTROLLER

- **AVR ATMEGA-16**

AVR ATMEGA 16 is 8-bit low power microcontrolle**r** based on the AVR enhanced RISC
Architecture. By executing powerful instructions in a single clock cycle, the ATMEGA-16 achieves through puts approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.
It is used to convert analog signal into digital It is a byte oriented two wire serial interface 8 channel, 10 bit analog to digital convertor the Atmel ATmega16 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications

C] RF MODULE: In this project we use CC2500 of RF module for transmission of wireless alert information from transmitter to receiver station

Fig 5: CC2500 trans-receiver

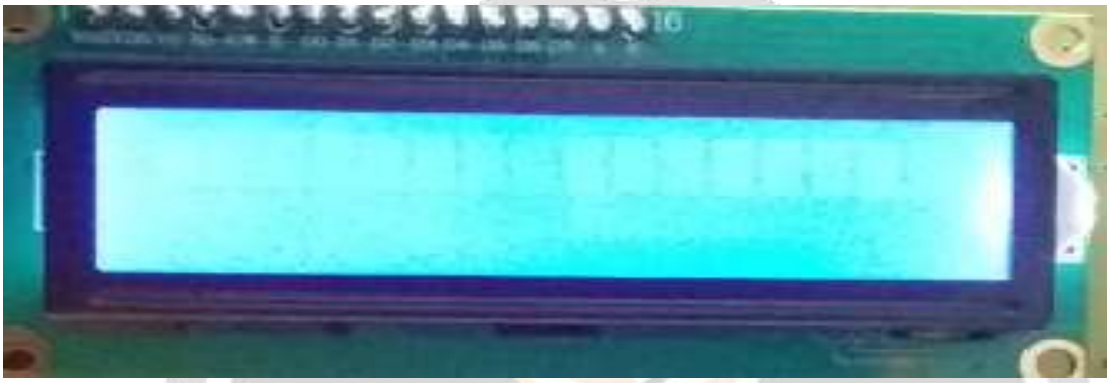
FEATURES:

- It supports Multiple Baud rates.
- Works on ISM band (2.4 GHz) which is reserved internationally.
- Supports multiple frequencies within the same band rate thus avoiding data collision.
- No complex wireless connection software required.
- Designed to be as easy to use as cables.
- Works on 5-9v DC supply.

BUZZER:
A piezoelectric buzzer is used .This buzzer is used in case of warning if critical level is crossed by the sensor.

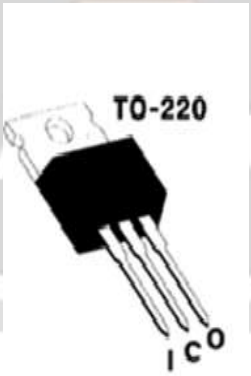
LCD:

In the monitoring section, LCD is connected to display the output of different sensor.



7805:

7805 is part of 78xx IC which acts as a voltage regulator. In circuit there may be fluctuations resulting in not providing fixed voltage output. A voltage regulator IC maintains the output voltage.



Ardunio328/P:

Aurdino328/P is based on ATMEGA328/P and is the central control of all transmitter section. It consist of total 28/32 pins. Pin A0 to A5 are analog in nature, 14 digital input output pin, a 14MHz quartz crystal, a USB connection, a power jack and reset button. It operates on external supply of 6 to 20 volt. The recommended range of using Aurdino328/P is 7V- 12V. ATMEGA328/P has 32KB in system of self-programmable flash memory and 1 Kbytes of EEPROM**.**

V. CIRCUITDIAGRAM:

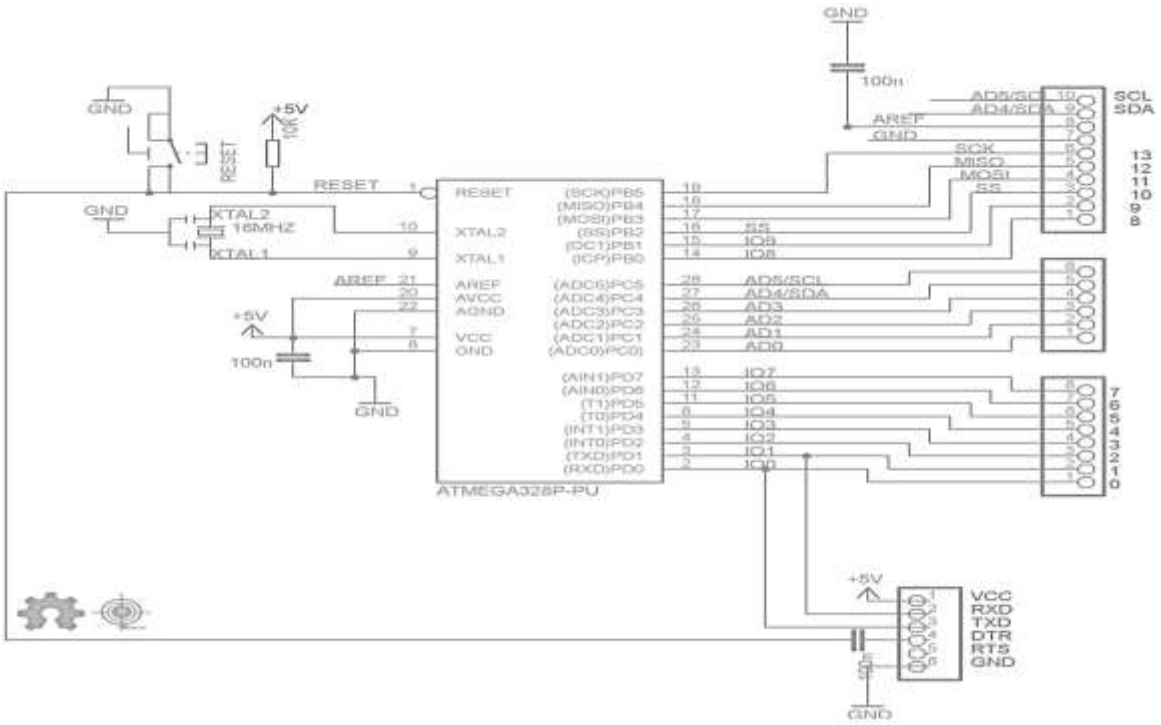


Fig 6Circuit diagram of Transmitter

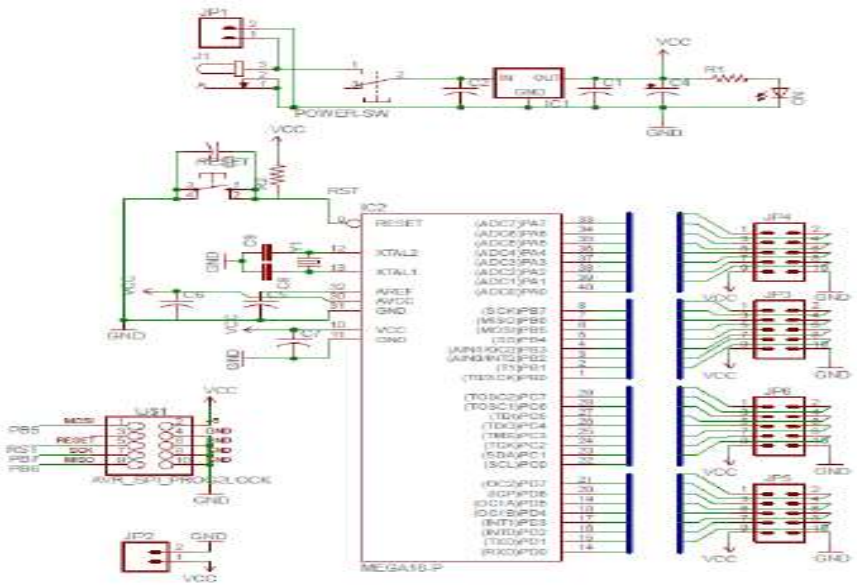


Fig 7:Circuit diagram ofRepeater

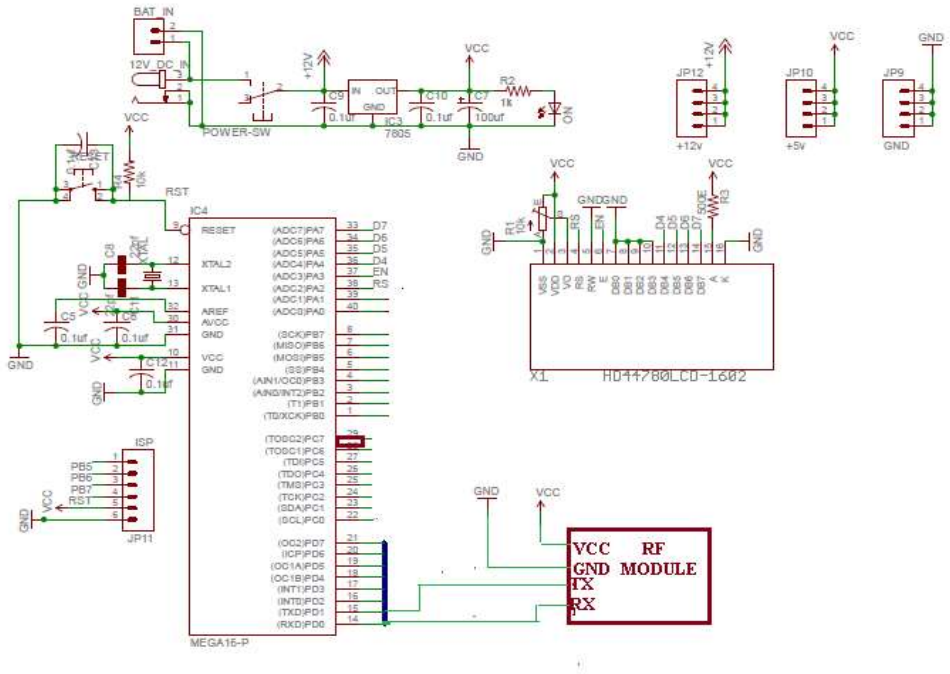


Fig 8:Circuit diagram of Receiver

VI. RESULT AND DISSUSION:

Air quality test: Air quality test is done by MQ-4 sensor. When MQ-4 sensor detects presence of CH4, LPG and natural gases above the critical value then an alert message will be send from transmitter section as "GAS DETECTED" to the monitoring section on LCD display. At the same time buzzer will automatically get ON.

Fig: Gas sensor test result

Helmet removal test: Smart helmet removal test is done by infra-red sensor. When miner removes his helmet from his head, that is detected by the transmitter section which sends "HELMET REMOVED" signal to the monitoring section which shows on LCD display and buzzer will automatically get ON.

FIG: Helmet removal test

Collision sensor test: Collision sensor test is done by using MMA7461L accelerometer. When object is fall on helmet "FALL DETECTED" alert massage will send by the transmitter section to the receiver section also the buzzer will automatically get ON.

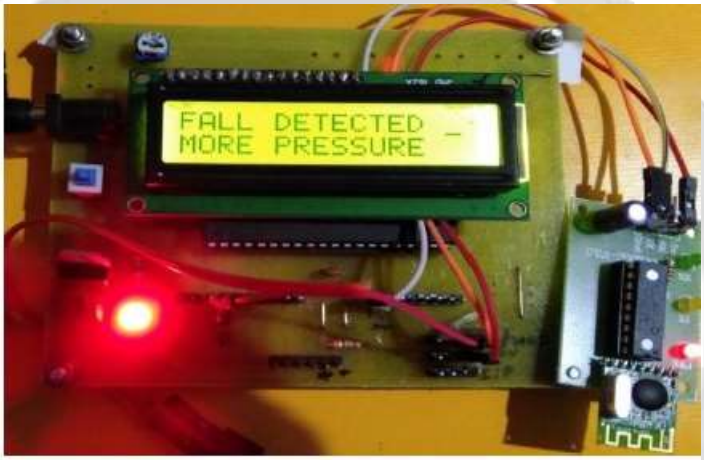


Fig: Test result of collision sensor

VII. CONCLUSIONAND FUTURE SCOPE:

A real time monitoring and data alert system is developed to detect dangerous events like presence of harmful gases, helmet removal by the miner and heavy object fall on the miners head and send respected information to the receiving section. So, the rescue operation of miners can be carried out.

The system can be enhanced further. The system can be improved by adding more measuring devices to check miners' blood pressure and heart rate**.**

REFERANCES:

1. C. J. Behr, A. Kumar and G.P. Hancke, "*A Smart Helmet for Air Quality and Hazardous Event Detection for the Mining Industry", IEEE 2016.*
2. Ge Bin, LI Huizong, "*The Research on ZigBee-Based Mine Safety Monitoring System"*, 2011 IEEE.
3. Tanmoy Maity, Tanmoy Maity, *"A Wireless Surveillance and Safety System for Mine Workers based on Zigbee"*, 1st Int'l Conf. on Recent Advances in Information Technology | RAIT-2012 | 2012 IEEE
4. Abhijeet Kumar Student Member IEEE, 1Harish KumarMember IEEE, 1V.N. Pandey, 2D.K.P Singh, 3S.K. Chaulya *"Gas Monitoring and Power Cut-off System for Underground Mines",*2012 7th IEEE Conference on Industrial Electronics and Applications (ICIEA).
5. CHENG Qiang, SUN Ji-ping, ZHANG Zhe, ZHANG Fan, *"ZigBee Based Intelligent Helmet for Coal Miners",*2008 IEEE1National Key Lab of Coal Resources and Safety Mining,China University of Mining and Technology,Beijing 100083,China,
6. M. A. Hermanus, *"Occupational health and safety in mining—status, new developments, and concerns,"*The Journal of The Southern African Institute of Mining and Metallurgy, vol. 107, pp. 531-538, Aug. 2007.
7. A.P. Squelch, *"Virtual reality for mine safety training in South Africa,"* The Journal of The South African Institute of Mining and Metallurgy, pp. 209-216, July 2001.
8. C. Qiang, S. Ji-ping, Z. Zhe and Z. Fan, *"ZigBee Based Intelligent Helmet for Coal Miners,"*IEEE World Congress on Computer Science and Information Engineering (WRI 2009), 31 Mar. -2 April 2009, vol. 3, pp. 433–435, 2009.
9. H. Hongjiang and W. Shuangyou, *"The application of ARM and ZigBee technology wireless networks in monitoring mine safety system,"*IEEE International Colloquium on Computing, Communication, Control, and Management (ISECS 2008), 3-4 Aug. 2008, Guangzhou, pp. 430–433, 2008.
10. X. Liu, J. S. Huang and Z. Chen, *"The research of ranging with timing over packet network for the mine safety application,"* Journal of Networks, vol. 7, no. 7, pp. 1054–1062, Jul. 2012.
11. W.R.Heinzalman, A. Chandrakasan, H. Balakrishnan, "*An application specific protocol architecture for wireless microsensor networks",* IEEE Trans. on Wireless Com., 2001, vol. 1, pp. 660-70.
12. Thanigaivelu, Kotiswaran, Murugan, Krishnan, "*Grid-based Clustering with Predefined Path Mobility for*Mobile Sink Data Collection to Extend Network Lifetime in Wireless Sensor Networks", *Academic JournalIETE Technical Review,* Mar/Apr2012, Vol. 29 Issue 2, p133.
13. X. Wang, X. Zhao, Z. Liang, M. Tan, "Deploying a Wireless Sensor Network on the Coal Mines", *Proc. of theInt. Conf. on Network Sensor and Control*, London, UK 2007, pp. 324-328.
14. P. Baronti, P. Pillai , Vince W.C. Chook , S. Chessa, A. Gotta, Y. Fun Hu, "Wireless sensor networks: ASurvey on the state of the art and the 802.15.4 and ZigBee standards", *Computer Communications*, vol. 30,2007, pp. 1655–1695.
15. M. Bai, X. G. Zhao, Z. G. Hou, M. Tian, "A wireless sensor network used in coal mines", *Proc. of the Int. Conf. on Network Sensor and Control*, 2007, pp. 319 - 23.